HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII
Under the joint supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE
AND THE UNIVERSITY OF HAWAII

REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION

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HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU

[Under the joint supervision of the Office of Experiment Stations, U. S. Department of Agriculture, and the University of Hawaii]

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INTRODUCTION

The restrictions placed on the tonnage of sugarcane and pineapples have led the various plantations of Hawaii to become interested in determining what other crops can best be grown on the lands at present not being utilized for the production of these two major crops. This has led to a rather intensive study of the possibilities of the more promising minor agricultural crops. In this work, the experiment station has been able to be of material assistance to the larger agricultural interests, as well as to the small farmers and homesteaders who habitually look to the station for advice and assistance in dealing with the problems arising in connection with the production of various agricultural crops and the raising of livestock and poultry.

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Considerable attention was given to the formulation of tentative plans for the utilization of a portion of the sugar-processing tax in assisting in the further development of the minor agricultural industries. These plans have included general fruit and nut investigation and extension, as well as fertilizer and cultural studies with the avocado and Macadamia nut; cultural and processing investigations of the edible canna as a source of commercial starch; soil survey of the principal islands; rat eradication; fruit fly and melon fly control measures; and liver fluke studies.

PROGRESS REPORT

Study of the fertilizer practices used in the diversified agriculture of the Territory has been continued. The high rentals and taxes on most of the agricultural lands make it imperative that intensive and low-cost production methods be used. With most of the small farmers, fertilizers represent their largest cash cost. As a result of fertilizer experiments, it has been possible to modify general fertilizer formulas to meet the needs of specific crops in different districts and effect an appreciable saving in costs. The response to fertilizer is usually so marked that relatively simple experimental lay-outs suffice and the cost of the experiment to the grower is negligible.

The Mitscherlich pot method continues to offer promise as a means of determining the available plant food in a soil. Such a pot test is made in conjunction with all field fertilizer tests conducted by the station. It is felt, however, that for such diverse crops as cabbage, potatoes, rice, and coffee, it is necessary to establish, by actual experiments with each crop, the correlation between results of pot and field tests. During the past year, special attention was given to potatoes in this regard. Sufficiently positive correlation was found between pot and field results to justify use of the pot test to indicate the fertilizer formula that the potato grower should use for his fall potato plantings. Continued study of indicator plants for the Mitscherlich method has shown panicum grass (*Panicum purpurascens*) to have some outstanding advantages over Sudan grass in its hardiness and ease of handling. Its chief disadvantage is its lack of sensitiveness to potash.

Grading and scoring of Macadamia nuts by the methods developed by the station are becoming of increasing usefulness to the industry. Such grading and scoring methods are being used as the basis for selection of seed and grafting material for the present plantings. Plans for improvement of bearing orchards by the elimination of undesirable trees are based on the grading methods. It is also probable that the price paid for nuts will soon be on the basis of the ratio of unshelled nuts to grade 1 kernels. Storage experiments completed during the year have given rise to a practicable method of holding the nuts without appreciable deterioration for at least a year. Improper storage methods have been one of the chief causes of poor quality of nuts from the Kona district. A method has been worked out by the station whereby the Kona growers will cure, hand-crack, and grade the kernels at Kailua. The graded kernels will then be shipped to market or dehydrated and stored for future consignment.

Study of the coffee plant has proceeded from various standpoints In cooperation with the agricultural extension service of the University

of Hawaii, a bulletin was published on the Coffee Cultural Practices in the Kona District of Hawaii (*8*).[1] Coffee fertilizer experiments in Kona continue to verify the results of previous years, that is, that on the Kona soils the coffee plant requires large amounts of additional nitrogen and potassium, with much smaller quantities of phosphorus, to mature the coffee berry. Growers using a 9–5–13 fertilizer formula,[2] based on the station's experiments, report uniformly good results. Chemical determinations of the nitrogen and ash constituents of a series of samples of coffee pulp, bean, and parchment skin from the central Kona fertilizer experiment, show marked differences due to fertilizer treatment and encourage the belief that fertilizer requirements of the coffee may be learned by analysis of the fruit.

New lines of work inaugurated were as follows: (1) Extension of the Mitscherlich pot-test method to include certain vegetables and cereal crops, such as cabbage, potatoes, and rice; (2) growth and fruiting of the coffee plant as affected by variation in location and fertilizer treatment; (3) pineapple bran versus beet pulp for dairy cows; (4) control of the liver fluke; (5) cassava-coconut oil-cake meal as a part of the ration fed to dairy cows; (6) miscellaneous byproducts of Hawaiian industries for swine feeding; and (7) isolation of carotene from papaya (*Carica papaya*).

Old lines of work completed or suspended included (1) pigeonpea breeding and selection, (2) sprouted oats for correcting breeding troubles of dairy cows and brood sows, (3) pineapple bran versus beet pulp for dairy cows, (4) value of alfalfa hay as a supplement to green roughages fed to dairy cows, (5) raw sugar as a supplement to rations fed to milking cows, (6) cassava-coconut oil cake as a part of the ration fed to dairy cows, (7) Hawaiian fruits as feed for swine, (8) plantation back-yard poultry houses, (9) gizzard worm control in Hawaii, (10) chemical and biological studies of protein in pigeonpea, (11) a chemical study of some Hawaiian plants (*a*) poisonous plants, (*b*) passion fruit, and (12) the isolation of carotene from papaya and other Hawaiian fruits. (This last project was inaugurated and completed during the year.)

Experiments carried on by the agronomy division on the various islands throughout the Territory included those with range grasses, pigeonpeas, rice, green manures, forage, soiling, and root and vegetable crops such as taro, sweetpotatoes, lettuce, and tomatoes. A bulletin giving the results of the investigations concerning Napier or elephant grass was published (*9*).

A bulletin showing the results of feeding a ration containing 25 percent of cane molasses over a period of 8 years was published (*3*). The manuscript for an article, indicating the ineffectiveness of sprouted oats in correcting breeding troubles in dairy cows and brood sows, was submitted for publication (*4*). A dairy herd of 54 animals of all classes was maintained for experimental purposes throughout the year, as were a small herd of swine and a flock of poultry of sufficient size for carrying out the various experiments which have been under way.

The chemical division investigated the fertilizer requirements of the more promising minor crops (coffee, potatoes, rice, Macadamia nuts). Considerable attention was given to the solution of technical problems arising in connection with the development of the Macada-

[1] Italic numbers in parentheses refer to Literature Cited, p. 28.
[2] That is, one containing 9 percent of nitrogen, 5 percent of phosphorus, and 13 percent of potassium.

mia-nut industry. A detailed chemical and general study was made of the more important range grasses of the Hawaiian Islands. The manuscript for a bulletin entitled "Factors Affecting the Chemical Composition of Pasture Grasses" was submitted for publication. Special chemical investigations were made of the composition of certain poisonous and alkaloid-producing Hawaiian-grown plants. The chemical constituents of the avocado and papaya were further investigated.

The horticultural division continued its activities in connection with the development of the Hawaiian Economic Tropical Arboretum, and a total of over 600 species and varieties of economic promise have been started and are in various stages of development, ranging from year-old seedlings to mature trees. Cultural and breeding studies of akala berries, coffee varieties, passion fruit, avocados, mangoes, litchi, lungan, etc., have been continued. Numerous successful grafts of the litchi on seedling stocks were made. A bulletin entitled "The Edible Passion Fruit in Hawaii" is in press.

The nutrition laboratory continued its vitamin studies of Hawaiian fruits, vegetables, and sea-food products. The manuscript for a bulletin, reporting the results of chemical and nutritional studies of a considerable number of Hawaiian fruits was submitted for publication. Articles were issued during the year in other publications on the nutritive value of green immature soybeans (*6*); the spleen, hemoglobin, and erythrocytes in nutritional anemia of the rat (*2*); and guava juice as a preventative of scurvy (*5*).

The poultry division developed an economical back-yard poultry house adapted to use on plantations. It found that artificial illumination increased egg production 7 percent. Tree kale proved slightly superior to green alfalfa for egg production. A circular giving the results of turkey-raising experiments was issued during the year (*1*).

The soil physics division continued its investigations of the water-holding peculiarities of Hawaiian soils. Work has centered about the precise determination of the silica-sesquioxide ratio and the range of available soil moisture.

The Haleakala substation (see also p. 26), on the Island of Maui, continued its experiments with range grasses and other forage crops at varying elevations. Variety tests with potatoes, pigeonpeas, and numerous fruits and vegetables were under way throughout the year. The Kona substation (see also p. 27), on the Island of Hawaii, developed increased plantings of various species and varieties of coffee, avocados, mangoes, citrus, and numerous other fruits which offer promise for that section. Fertilizer experiments with coffee and Macadamia nuts were under way.

The station budget for the year was $93,066, made up as follows: Territorial and university special funds, $31,000; Hatch fund, $15,000; Adams fund, $13,000; United States Department of Agriculture funds, $34,066. The last item was reduced $1,089 by impoundage. The budget for the previous year totaled $86,650.

PROJECTS

Progress was made in all of the 48 active projects of the station, while a few projects were closed or suspended owing to the completion of the particular line of investigation or to make way for some more pressing investigation, funds for which were not otherwise available.

Research projects active during the year, together with their leaders, were: Correlation between the magnitude of the sesquioxide ratio in an extracted soil colloid and soil-moisture availability (H. A. Wadsworth); breeding and selection of pigeonpeas, breeding, yield, and adaptability studies of forage crops, life-history and growth-habit studies of grasses and legumes under tropical conditions (C. P. Wilsie); varietal, cultural, and propagation studies of citrus, culture and breeding of Hawaiian raspberries (akala berry, *Rubus* sp.), and varietal, cultural, and propagation studies of Macadamia nuts (W. T. Pope); factors affecting chemical composition of Macadamia nuts (J. C. Ripperton); varietal, cultural, and propagation studies of coffee (W. T. Pope); rejuvenation of old coffee plantings, and variations in the chemical composition of fruit and vegetative tissue of the coffee plant as affected by location and fertilizer treatment and their relation to problems of growth and fruiting (J. C. Ripperton); the Mitscherlich pot test as a means of determining the nutritional requirements of certain vegetables and cereal crops, such as cabbage, potatoes, and rice (J. C. Ripperton and D. W. Edwards); variety tests and breeding studies of vegetable crops (C. P. Wilsie); sprouted oats for correcting breeding problems of dairy cows and brood sows, comparative value of various grasses and legumes in the Tropics as roughages for dairy cattle and most effective and economical methods of utilizing such roughages, pineapple bran versus beet pulp for dairy cows, value of alfalfa hay fed as a supplement to green roughages fed to dairy cows in Hawaii, raw sugar as a supplement to rations fed to milking cows, control of liver fluke in Hawaii, cassava-coconut oil-cake meal as a part of the ration fed to dairy cows, Hawaiian fruits as feeds for swine, miscellaneous byproducts of Hawaiian industries for swine feeding (L. A. Henke); plantation back-yard poultry houses, batteries for laying and breeding hens, artificial illumination for laying stock, tree kale (chou moellier) as a source of green feed for poultry, gizzard worm control in Hawaii (C. M. Bice); vitamin studies of Hawaiian foods and feeds, chemical and biological studies of protein in pigeonpeas, chemical and biological studies of the opihi (shellfish), studies of the transfer of vitamin B from rice bran to various types of plant tissues, as a result of pickling them with salt and rice bran (C. D. Miller); study of the sterol content and vitamin value of avocado oil (L. N. Bilger); iodine content of Hawaiian foods (E. M. Bilger); chemical studies of Hawaiian plants, (1) poisonous plants, (2) alkaloid-containing plants; isolation of carotene from papaya (L. N. Bilger).

PUBLICATIONS

The following is a list of publications of the station during the year covered by this report:

Report of the Hawaii Agricultural Experiment Station, 1934; Bulletin 72, Napier Grass (*Pennisetum purpureum*); A Pasture and Green Fodder Crop for Hawaii, by C. P. Wilsie and M. Takahashi; Bulletin 73, Cane Molasses as a Feed for Dairy Cows, by L. A. Henke; Bulletin 74, The Edible Passion Fruit in Hawaii, by W. T. Pope (in press); Bulletin 75, Coffee Cultural Practices in the Kona District of Hawaii, by J. C. Ripperton, Y. B. Goto, and R. K. Pahau; and Circular 10, Turkey Management in Hawaii, by C. M. Bice.

Articles contributed by members of the station staff and published elsewhere than in the regular station series of bulletins and circulars included the following:

Juice of Guava Prevents Scurvy, by C. D. Miller (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, p. 48); Plantations Offer Opportunities, by H. A. Wadsworth (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, p. 3); A Note on the Relationship between the Chemical Composition of Soil Colloids and Two of Their Properties, by H. A. Wadsworth (Soil Sci. 39: 171–176. 1935); Light Showers and Dew as a Source of Moisture for the Cane Plant, by H. A. Wadsworth (Hawaii. Planters' Rec. 38: 257–264. 1934); Sugar By-Products as Cattle Feed, by L. A. Henke (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, v. 2, p. 16); Agricultural Observations on the Mainland, by L. A. Henke (Honolulu Star-Bull., Sept. 15, 1934, Sept. 22, 1934); Observations at Mainland Experiment Stations, by L. A. Henke (Honolulu Star-Bull., Sept. 29, 1934, Oct. 6, 1934); The Algaroba Bean as a Feed for Hawaii Livestock, by L. A. Henke (Univ. Hawaii Agr. Ext. Serv. Agr. Notes No. 107, Nov. 2, 1934, pp. 1–2); How Much Should a Dairy Cow be Fed, by L. A. Henke (Univ. Hawaii Agr. Ext. Serv. Agr. Notes No. 114, Mar. 29, 1935, pp. 1–3); Pineapple Bran as a Feed for Mules, by L. A. Henke (Hawaii Agr. Expt. Sta., Anim. Husb. Div. Prog. Notes No. 7, Oct. 1934, pp. 1–8); Green Panicum Grass vs. Green Sudan Grass for Dairy Cows, by L. A. Henke (Hawaii Agr. Expt. Sta., Anim. Husb. Div. Prog. Notes No. 8, Jan. 1935, pp. 1–9); A General Report of the Animal Husbandry Division of the Hawaii Agricultural Experiment Station for the Fiscal Year Ending June 30, 1934 (Hawaii Agr. Expt. Sta., Anim. Husb. Div. Prog. Notes No. 9, Mar. 1935, pp. 1–15); Fattening Beef Steers on Feeds Produced in Hawaii, by L. A. Henke (Hawaii Agr. Expt. Sta., Anim. Husb. Div. Prog. Notes No. 10, May 1935, pp. 1–8); Natural Crossing in the Pigeonpea, by C. P. Wilsie and M. Takahashi (Jour. Agr. Research 49: 923–927. 1934); Foreign Forage Plants are Studied, by C. P. Wilsie (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, p. 18); Poultry House Important Factor, by C. M. Bice (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, p. 21); Give the Baby Chick a Good Start in Life, by C. M. Bice (Univ. Hawaii Agr. Ext. Serv. Agr. Notes No. 113, Feb. 15, 1935); Many Fruits Do Well Here, by W. T. Pope (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, p. 29); The Spleen, Hemoglobin, and Erythrocytes in Nutritional Anemia of the Rat, by C. J. Hamre and C. D. Miller (Amer. Jour. Physiol. 111: 578–589, illus. 1935); The Nutritive Value of Green Immature Soybeans, by C. D. Miller and R. C. Robbins (Jour. Agr. Research 49: 161–167. 1934); Experiment Station in Busy Year, by J. M. Westgate (Honolulu Star-Bull. Hawaii Farm Ann., Dec. 8, 1934, p. 4); and A Chemical Investigation of the Fermentations Occurring in the Process of Poi Manufacture, by L. N. Bilger and H. Y. Young (Jour. Agr. Research 51: 45–50).

SOILS

Studies concerning the factors affecting the range of available soil moisture in local soils have resulted in the design and construction of a device which permits the determination of the moisture content-surface force curve of an unknown soil with considerable precision. It is expected that the device will permit determination of the permanent wilting percentages by indirect means when only small samples of material are available for study.

Fusion analyses of colloidal separates of Hawaiian soils indicate that such results only have comparable values when the method of extracting the colloids is specified and rigorously adhered to. Values of the silica-sesquioxide ratio for the colloidal material in a local sugar soil ranged from 1.18 to 1.59 in a series of preparations of this material although any one of them might be described as the colloidal material of the soil in question.

THE MITSCHERLICH POT METHOD OF DETERMINING SOIL AND PLANT REQUIREMENTS

Study of the correlation of results of field fertilizer experiments with those of the Mitscherlich pot test was continued. Especial emphasis was given to potatoes in this regard because of the present

local interest in this crop. The practical value of a preliminary pot test to determine the needs of the potato crop to follow are evident from the field experiments just completed. In one field, phosphates increased the yield over the no-phosphate plats from 35 bags to 105 bags (100 pounds per bag) of potatoes per acre, a gain of 70 bags. In another experiment, the response to phosphates was nil. Likewise, nitrogen produced increases as great as 40 bags in some fields and negligible increases in others. In no instances did any of the field experiments show response to potash. The Mitscherlich pot test appears to give reliable information regarding the response of potatoes to phosphates. As is well recognized, the pot method is of less value as an indicator of available nitrogen.

Continued study has been made of indicator plants for the Mitscherlich method. Sudan grass, which is the common indicator used locally, has certain disadvantages, chief among them being its very poor growth on certain types of soil. It is also considerably affected by adverse weather conditions, such as low temperatures, strong wind, etc. Panicum grass (*Panicum purpurascens*) has been used in a considerable number of soils to compare with Sudan grass. The former has been found to have fully as low an experimental error on good soils as Sudan grass. The planting material, which consists of a 1-inch section of a stem containing one node, can be obtained at all times and practically 100 percent of the cuttings grow. It grows vigorously in the highly hydrated upland soils in which Sudan grass makes feeble growth. Panicum appears to be less affected by adverse weather conditions. It is much less sensitive to potash deficiency, however, than Sudan grass. As an indicator of the field response of potatoes to phosphates, panicum appears equal, if not superior, to Sudan grass. Other indicator crops which are being studied are a series of varieties of rice. The high rate of transpiration and long maturing period are objections to this crop, although it is quite hardy.

FIELD CROPS AND FORAGE PLANTS

RICE

Pot studies were made in connection with the continuous field fertilizer experiment with rice in the Hanalei section of Kauai. The experiment is now in its third crop. Using a new formula, in which phosphorus and potassium were reduced to one-half the previous amounts, the rice growers of Hawaii produced excellent crops during the past year at a considerable saving in cost of fertilizer. This new formula was one of the results of the station's field and pot tests with rice.

PIGEONPEAS

The work on natural crossing was completed and the results published. A variety test, including eight promising selections, was laid out in random block arrangement. Seed yields were determined and four of the strains yielded approximately equal to or better than the standard variety "strain D." Fortunately the early selection work (resulting in the strain D variety) produced a very desirable type of plant which bore heavy crops of seed. The newer strains developed since then, while offering promise for certain uses and for certain areas, do not seem to be greatly superior to strain D. Further tests are to be carried on with the more desirable newly developed strains.

SOYBEANS

Studies were continued with 42 varieties of soybeans, including standard late-maturing southern varieties as well as a large number of newly introduced green vegetable types. For use in the manufacture of soybean products, yellow-seeded beans are preferred. The Yellow Biloxi Hybrid, Tokyo, Mammoth Yellow, and Edward all have yellow seeds, are medium to late in maturity, and have given excellent yields in plat tests. Biloxi is a valuable variety, for although it has dark-colored (brown) seeds, it produces heavy yields of both seed and forage. The Laredo and Otootan are promising for forage use. A great deal of local interest has been manifested in this crop as a possible supplemental crop for growth on sugar and pineapple plantations.

A number of green vegetable types have shown promise in preliminary trials. Station selections have been made from one of these introduced in 1932 (F. P. I. 80483) which have a more desirable seed color and are considerably better in yielding ability. The outstanding fault of many of the green vegetable types is their small growth and low seed yield. Breeding work would undoubtedly give worth-while returns with this crop under Hawaiian climatic conditions.

The manuscript of an article entitled "Seed Production Studies With Legumes in Hawaii" has been submitted for publication.

GRASSES AND LEGUMINOUS FORAGE CROPS

ADAPTATION STUDIES

Through the establishment of new grass gardens and continued observation on those planted 2 and 3 years ago, the role of species in adaptation has been shown more clearly.

According to preliminary nursery trials several recently introduced forage species offer considerable promise. Three grasses, known commonly as "finger grasses", *Digitaria pentzii*, *D. valida*, and *D. milangiana*, have been established by seed obtained through the courtesy of the Council for Scientific and Industrial Research, Australia. These species, originally introduced from Africa, are considered promising pasture grasses. Promising introductions from the Union of Soviet Socialist Republics include *Pennisetum glaucum*, *Eragrostis abyssinica*, and two alfalfa species. Four varieties of molasses grass (*Melinis minutiflora*) were obtained from Brazil. Molasses grass has done well both in extremely dry and fairly wet conditions, and if a variety could be found that would recover quickly after grazing, it would have a wide use in Hawaii.

At low to medium elevations where sufficient moisture is available, Napier (*Pennisetum purpureum*), kikuyu (*P. clandestinum*), molasses grass, Rhodes (*Chloris gayana*), Dallis (*Paspalum dilatatum*), Para (*Panicum purpurascens*), and guinea grass (*P. maximum*) were outstanding. On Maui a great increase in the plantings of kikuyu, molasses, and Napier grasses was observed. At the higher elevations, Temperate Zone species showed their forage possibilities. *Phalaris tuberosa*, orchard grass (*Dactylis glomerata*), tall fescue (*Festuca elatior*), rescue grass (*Bromus unioloides*), and the ryegrasses (*Lolium* spp.) were most promising. At 5,000 feet, *Phalaris tuberosa* made the greatest growth of all of these. Legumes desirable for higher elevations included mammoth red clover (*Trifolium pratense*

perenne), white clover (*T. repens*), wet-land trefoil (*Lotus uliginosus*), the vetches (*Vicia* spp.), and alfalfa. At 2,000 to 4,000 feet, kikuyu grass and wet-land trefoil appeared to make an excellent pasture mixture.

FREQUENCY OF CUTTING EXPERIMENTS

Alfalfa was cut at three stages, bud stage, one-quarter bloom, and full-bloom stage. The highest total yields to date have been obtained from the plats cut at the full-bloom stage. The greatest noticeable effect of cutting treatment was the immediate reduction in stand in the plats cut at the bud stage. This reduction in stand was most evident during the first 6 months of the experiment. An experiment was started to determine the effect of cutting treatment on the growth, composition, and persistence of Napier grass. It was desired to know whether Napier can be cut at 6- or 8-week intervals throughout the year and still maintain a good stand and high yield under conditions of adequate fertilization. This test will not be completed for 2 or 3 years.

LIFE HISTORY AND STRAIN STUDIES

Nine promising seedling strains of *Pennisetum purpureum* were planted in a well-replicated field-plat test for a comparison with the standard varieties of Napier and Merker. Preliminary yield results indicate that some of these seedling strains may be of superior value for agricultural use. Differences recorded include such features as size and hardness of stem, size of leaf, stooling habit, growth rate, and hairiness of stem and leaf.

PASTURE GRASSES

No new lines of work, relating to pasture grasses, were undertaken during the year. A bulletin entitled "Factors Affecting the Chemical Composition of Pasture Grasses" was submitted for publication. The salient features of this investigation, conducted in cooperation with the Parker ranch and the agricultural extension service of the University of Hawaii, were: (1) The very large variation in phosphorus content shown by the same species when grown in different locations, (2) the lack of effect upon protein content under the above conditions, and (3) the considerable differences between grass species in their content of protein, lime, and phosphorus, even when grown under identical conditions.

The pasture-grass management and fertilizer experiment, which was installed on Grove farm, Island of Kauai, in January 1934, has failed to yield material suitable for chemical analysis owing to the failure of carpet grass (*Axonopus compressus*) to reestablish itself after certain of the plats were plowed. The plowing, which was more thorough than the usual ranch practice, had the unforeseen effect of starting a plant succession in which the climax species (carpet grass) will not be reached for several years. This large experiment was therefore replaced during the year by a very small one which embodies the same treatments, but on all "plowed" plats carpet grass was replanted and the plats are being maintained free from extraneous species, in the expectation that under these conditions the carpet grass will reestablish itself much more quickly.

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FRUITS, VEGETABLES, AND NUTS

AKALA OR NATIVE RASPBERRY

Attempts to hybridize the akala, native raspberry of Hawaii (*Rubus hawaiiensis* and *R. Macraei*), and introduced species of *Rubus*, were continued. Seed from 32 crosses, made in April 1934, was obtained late in June 1934. These were carefully planted early in July in the germination beds of the propagating house at the station in Honolulu. Unfortunately, none of the seeds sprouted under any of the methods of treatment to induce germination. It has been observed that the seeds of the akala itself are very difficult to germinate, about one seed in a thousand germinating when planted under greenhouse conditions. Another species, the Andes blackberry (*Rubus glaucus*), has been obtained from A. M. Cramer of Wonosobo, Java, for further hybridization attempts with the akala.

ANNONACEOUS FRUITS

The annonaceous fruits—custard-apple, sugar-apple, cherimoya, ilama, and soursop—are promising fruits, and it has been found that they can all be easily grafted by either the side-tongue graft or the whipgraft on soursop seedlings which usually prove vigorous.

Graft wood of two hybrid annonas, new to this Territory, has been received through the kindness of the Bureau of Plant Industry, United States Department of Agriculture. The propagating material was taken from trees growing on David Fairchild's place in Florida. This wood consisted of two kinds—*Annona squamosa* (sugar-apple)$\times$ *A. cherimola*, and *A. squamosa* $\times$ *A. cherimola* $\times$ self. The grafts have taken in sufficient numbers and have made such vigorous growth as to indicate the success of the introduction. The cherimoya, however, should be grafted on rootstocks of its own species as they are better adapted to the cooler soils of the highlands where this species naturally fruits well.

PASSION FRUIT

The station has investigated the yellow edible passion fruit (*Passiflora edulis* var. *flavicarpa*) as a minor project for a number of years until it now promises to become a commercial success. Methods of culture and propagation, as well as of processing the fruit and fruit products, have been worked out. One concern has already made a preliminary planting now in fruit and is commencing to plant 250 acres at the present time with the view to extending the acreage as rapidly as possible. The manuscript of a bulletin on this crop was submitted for publication.

POTATOES

The Bliss Triumph variety of potato has continued to be the outstanding early variety and British Queen the standard late variety. The Katahdin has given fair yields in preliminary tests, the tubers being excellent in shape and quality. Comparative tests with seed stocks from different sources have shown the importance of using northern-grown certified seed potatoes. Excellent results have also been obtained with seed stocks grown one generation in Hawaii (and carefully field-rogued) in comparison with imported certified seed and locally grown seed from nonrogued plats. Locally grown seed more than one generation removed from northern-grown certified stock is

not recommended for planting. Yields of third- and fourth-generation Hawaiian stocks fell down badly compared with imported certified stocks or first-generation Hawaiian-grown stocks. Potato yields in Hawaii are not very high as compared with yields in potato sections of the mainland. The vine growth is much smaller and the time for the crop to mature is shorter, in the winter months seldom extending over more than 80 to 100 days. The length of day is undoubtedly a factor, and the short days in Hawaii may make impossible here the exceptionally high yields of potatoes obtained elsewhere.

SWEETPOTATOES

Varietal studies of sweetpotatoes were continued. A collection of 50 varieties has been added to the station list. Twenty-two of these were obtained from Kauai through the courtesy of J. S. B. Pratt, 22 from Maui through the courtesy of E. S. C. Handy, and 6 from Oklahoma through the courtesy of A. J. Stiles, of Rush Springs, Okla.

Yield results of the last 7 harvests have been summarized and among the 10 highest yielding varieties, 8 were station hybrids or seedlings. This indicates the possibilities in the breeding of sweetpotatoes, for all of these 10 averaged more than 20,000 pounds per acre in a 6-month growing period.

LETTUCE

Lettuce breeding has been continued with the emphasis on good heading characteristics in plants grown at low elevations. The most promising material now available includes a number of selections from the F_2 progeny of a cross between Accession no. 1801 and Mignonette. The most promising selections will be tested at higher elevations as well as at low elevations during the next growing season.

TOMATOES

Variety tests have shown the superiority in yield, shape of fruit, and quality of Break O'Day, Marglobe, New Stone, and Pritchard varieties. The Break O'Day has given the highest yields in the last 3 years. Cultural experiments have shown the value of pruning and staking the plants so as to keep all ripening fruits off the ground.

GARDEN BEANS

Tests at the Pensacola Street station have continued to show the excellent qualities of the green pole bean, Accession no. 2291. An effort has been made to trace the history of this bean but so far its identity is not wholly known. It outyields Kentucky Wonder both in green pods and in seed production and possesses excellent table quality.

Interest in beans has increased among certain sugar planters, and the agronomist has cooperated with them in locating seed sources, particularly of some of the newer strains developed recently by plant breeders.

PEANUTS

High yields have been obtained from several varieties of peanuts during the last 3 years. Virginia Jumbo, Virginia Bunch, Tennessee Red, Spanish, and Valencia have all given good results. Yields have ranged from 2,100 to 4,600 pounds per acre in the last three crops. The peanuts are not very clean when harvested from the heavy red-

dish local soils, a factor which must be considered in the marketing of the product.

SWEET CORN

Sweet corn hybrids between Guam and Narrow Grain Evergreen, Country Gentleman, and Golden Cross Bantam have been back-crossed to the Guam parent. It is hoped to incorporate into a sweet strain the climatic adaptation and disease resistance of the Guam variety. The Guam corn is usually quite dependable even when a bad infestation of corn leaf hoppers is present. These back-crosses will be observed for resistance to leaf hopper and corn stripe disease and a pure sweet strain will be isolated. A sweet strain that would give as dependable results as Guam corn would be exceedingly valuable.

STARCH CROPS

A collection of 23 taro varieties, including both dry-land and wet-land types, was added to the already large collection growing at the station. These are being maintained for varietal studies and as a source of planting material for experimental purposes. This crop is attracting considerable attention as a supplemental crop for use on otherwise idle pineapple fields (fig. 1).

Thirteen varieties of cassava and six of edible canna were grown for yield data and planting material for further variety tests.

MACADAMIA NUT

PROPAGATION, CULTURE, AND VARIETY STUDY

The technic of grafting the Macadamia-nut tree has been gradually improved until it is commercially practicable. The young grafted nursery stock has been found to withstand transplanting to their permanent place in the orchard. This is important in case any of the seedling trees, put out for top working, should lose vigor and require replacement with grafted trees of the same size. The successful outcome of any commercial orchard is dependent to a large extent on the standardization of the variety making up the orchard. The propagation studies of the station have made this possible. The station is even advocating the top working of bearing orchards to make possible a crop of uniform nuts instead of the wide variation in the nuts at present the rule in most of the bearing orchards. The smooth-shell variety (*Macadamia ternifolia* var. *integrifolia*) has been shown to possess the most valuable qualities, and the best trees of this variety are being used as a source of budwood for the grafting of this valuable and promising nut tree (figs. 2, 3, and 4).

STORAGE, GRADING, AND MARKETING

The Macadamia-nut storage experiment, begun in January 1934, was completed. The purpose of the experiment was to determine a feasible method of storing the nuts from the time of harvesting until they could be processed or sold. This is a highly important step in the commercial handling of nuts, since improper handling may lead to heavy losses. Without a practical method of storage, the nuts must be cracked and processed at once. This greatly increases the peak load on factory machinery and personnel for a short season. The methods studied included storage of the uncracked, cracked, dehydrated, and roasted samples in open and sealed containers.

Temperatures of storage were 20°, 32°, 40° F., cool-room temperatures (Nutridge, altitude 800 feet) and hot-room temperatures (Macadamia Nut Co. factory, Honolulu, at sea level).

At least four different types of deterioration were noted: (1) Absorption of foreign odors where uncracked nuts or kernels are placed in

FIGURE 1.—Taro used as an intercropping plant between young orchard trees.

cold storage in open containers, (2) mold infestation where the kernels are stored under moist conditions, (3) rancidity under conditions of prolonged storage and high temperature, and (4) break-down of tissue under conditions of high moisture content. This is accentuated by increasing temperature. Break-down of tissue is not apparent in the uncooked nut but is strikingly evident when the sample is oil-cooked. In the earlier stages of break-down brownish-red splotches appear in the tissue. As the break-down progresses, the entire nut turns a dark

chocolate brown. The texture, too, becomes tough or sometimes mealy, entirely devoid of crispness. Under the same conditions of cooking, the normal nut is light brown in color and crisp in texture.

FIGURE 2.—Macadamia interplanted with coffee in the Kona district. The coffee is topped at about 6 feet and the Macadamia is pruned high enough to preclude excessive shading of the coffee. This two-crop system would be a boon to the Kona district if it can be demonstrated that the association is favorable to both crops.

As a result of the experimental work, the following procedure for storage is recommended: (1) Husk the nuts as soon as gathered, as undesirable fermentation and heating of the unhusked nuts will begin within a few hours if held in sacks under poorly ventilated conditions;

(2) place the husked nuts, 3 or 4 deep, in wire-bottom trays and store for 1 month in a curing house in a dry location and having a good circulation of air throughout, after which the nuts may be cracked

FIGURE 3.—A well-shaped Macadamia tree in the Kona district. It has an open head and good spread with little tendency toward the development of rank water shoots, characteristic of many trees of this species.

at once or sacked and held in the curing house 2 months longer; (3) dehydrate the cracked nuts at about 160° F. to approximately 2 percent of moisture and store in sealed containers in cold storage

at 40°. Under such conditions, the nuts may be held for about 12 months.

Using the methods of grading and scoring developed by the station, a total of 287 samples of Macadamia nuts were tested. From the

FIGURE 4.—Grafted Macadamia nut tree 2 years old. The crown branches may be properly developed and the tree has no inclination to become abnormally tall.

results of these tests some important conclusions can be drawn. The commercial groves, which consist entirely of seedling trees, show a high degree of variability in quality of nuts. Using the grading methods, it appears feasible to test all doubtful trees as to nut quality and eliminate or top work those falling below a certain standard. It

seems probable that in the near future commercial lots of nuts will be purchased on the basis of the yield of grade 1 nuts. Nuts from the best tree have a ratio of nut to grade 1 kernel equal to 2.9 while with other trees in the same orchard and presumably the same source of seed the ratio is as high as 6. Because of the overhead incident to gathering, curing, cracking, etc., the latter is scarcely worth handling. Using a hypothetical overhead cost, and selling price, a 3-to-1-ratio nut would be worth 10 cents per pound of unshelled nut; a 4-to-1, 6 cents; a 5-to-1, 3.4 cents; and a 6-to-1, 1.7 cents per pound. General samples submitted by the local Macadamia Nut Co. from commercial samples showed variations of from 3.5 to 7.

Special attention was given to the Macadamia-nut plantings in the Kona district. These are chiefly interplanted among coffee and are of the "rough-shell" variety. It has been difficult to market the nuts from Kona due partly to the characteristic differences between the rough-shell and the more common smooth-shell variety. Careless methods, used by the coffee growers, in curing and storing the nuts have also been a contributing factor. An experiment was conducted cooperatively with the growers and the local Macadamia Nut Co. to determine the feasibility of curing, hand-cracking, and grading the kernels at Kailua, where the hot, dry conditions are ideal for curing. The rough-shell kernel is of a harder texture than that of the smooth-shell and is little bruised by hand cracking. Elimination of the shell and low-grade kernels in Kona saves about 75 percent of the freight on shipment to Honolulu. It also enables each grower to be paid in terms of grade 1 quality of kernel rather than a fixed rate per pound of unshelled nuts. This procedure is to be tried out commercially in Kona during the current year.

COFFEE

STANDARDIZATION OF VARIETIES

The standardization of varieties of coffee trees by grafting is one of the outstanding results of the station's work. A large part of the coffee experimental orchards will eventually be standardized by grafting with budwood from outstanding trees of the respective varieties. The young trees are grafted readily by either the cleft-graft or the whipgraft union. These methods of grafting are described in detail in a circular of the station (7). Coffee seedlings of several new varieties have been established and placed under test to determine their adaptability to Hawaiian conditions (fig. 5).

FERTILIZER EXPERIMENTS

The Kainaliu fertilizer experiment (Fukuda) continued to show the same striking differences in yield as heretofore. The very heavy yields of last year—206 bags (100 pounds per bag) per acre for the nitrogen-phosphorus-potassium (N–P–K) fertilizer—resulted in a much lighter crop this year. The complete fertilizer (N–P–K) plats yielded at the rate of 96 bags per acre, the nitrogen-potash (N–K) fertilizer, 77 bags; the nitrogen-phosphorus (N–P), 16 bags; the nitrogen alone, 19 bags; and the no-fertilizer plat, 23 bags of coffee cherries per acre. This great fluctuation in yield of the coffee tree from year to year is characteristic of the multiple vertical pruning system, and it is only by carrying the experiment over a period of years that this extreme fluctuation can be compensated for. It is

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probable that the difference in yields of the N–P–K and N–K plats is due to this factor rather than lack of phosphates. The upper Kona experiment (Takashiba) is already showing unmistakable signs of lack of nitrogen in the no-nitrogen plats. The experiment was begun just 1 year previous, in June 1934. This serves to illustrate the dependence of the coffee industry in Kona on fertilizer.

CHEMICAL COMPOSITION

A series of samples of coffee cherries from the Kainaliu experiment were separated into their component parts, namely, pulp, fermentation liquid, parchment skin, and bean. Each component was analyzed for nitrogen, phosphorus, calcium, magnesium, potassium, sodium, and total ash. The results show significant differences in the absorption of ions for the different fertilizer treatments, particu-

FIGURE 5.—Two-year-old coffee trees produce their first blossoms in connection with rapid growth. Kona substation.

larly with respect to potash. The plats receiving no potash were markedly lower in this constituent. The coffee bean showed much less fluctuation among the five replicates than the pulp.

Mitscherlich pot tests of soils from the north Kona and upper Kona fertilizer experiments showed a rather low potash content so that it is planned to study the potash availability of Kona coffee soils by means of pot tests as well as chemical tests.

Samples of coffee cherries taken at different stages of dieback were analyzed for nitrogen and mineral constituents. The results indicate no consistent trends with increasing dieback. This may be due to the fact that moisture was the limiting factor rather than plant food and desiccation was too rapid to allow of any appreciable reabsorption of mineral plant food.

COFFEE-PULP COMPOST

Study of methods of composting coffee pulp was continued at the Kona substation. Previous methods, in which the coffee pulp was composted without admixture of other organic material, showed that

anaerobic decomposition is too slow to be practical in Kona. It was necessary to turn the pile once or twice to effect any material reduction in bulk. By alternating layers of parchment skin and pulp it was possible, at least in a small pit holding 1 ton of material, to induce rotting throughout the mass without turning. If composting of the pulp is to be practiced in Kona it must show some outstanding advantages, such as reduction of bulk or greater retention of fertilizer constituents, over the present method of accumulating in a pile to be subsequently carried to the field during the slack season. The present work is serving to emphasize to the farmer the value of coffee pulp as a fertilizer, and in many cases the farmers are careful to protect their pulp piles from rain and are returning it all to the fields. The practice used in other countries of placing the pulp in small pits dug at regular intervals among the coffee trees is being recommended instead of the present practice of scattering it over the surface.

PRUNING EXPERIMENTS

The experiments on pruning systems, systematic pruning, and dieback were continued. The pruning-systems experiment, comparing the systems used in Kona, include the multiple vertical, the topping, the leaning vertical, and the tall vertical systems. One plat is also included in which no pruning is practiced. The systematic pruning experiment purports to maintain the coffee tree at as constant a level of production as possible by removing and bringing out a constant number of verticals each year. The desirability of this from the experimental standpoint is well exemplified by the Kainaliu experiment, where the yield of the five nitrogen-potash plats in 1934–35 fluctuated from 60 to 230 pounds of cherries per plat. Several different ways of bringing out new verticals are being tried, namely, removing the old vertical, girdling, notching, breaking the old vertical over after sawing it half-way through. Girdling has produced new shoots below the girdle in well over 80 percent of the cases, and appears to have some commercial usefulness. Notching has not proven effective. Removing the old vertical is the surest method of inducing new shoots but causes the loss of a part of the tree for a season. Breaking over of the old vertical is of questionable value although it is effective in stimulating development of new shoots.

COFFEE DIEBACK

In the coffee dieback experiment, various methods of limiting the bearing surface are being tried, such as removing every third primary lateral, limiting the bearing surface on each primary lateral to about seven nodes by pruning off the tip and by stripping, and finally by limiting the upward growth of the new vertical by capping. The latter method seems to have commercial value under Kona conditions where the close plantings and limited sunlight cause weak, spindly upward growth. Capping restricts upward growth and produces shorter nodes and sturdier laterals. No appreciable dieback has occurred on any of the plats as yet.

ECONOMIC TROPICAL ARBORETUM

The Economic Tropical Arboretum has been enlarged until it now contains over 600 species. By including in this arboretum the older plantings of fruit and nut trees, the station now has a collection of

plantings, some dating back to 1895, and possibly to 1893, when the present station reservation was set apart for experiments in agriculture and horticulture, several years before the Hawaiian Islands became a part of the United States. These older plantings are of great value in demonstrating the adaptability of the species in question to local conditions. The range in altitude from 90 to 1,400 feet provides a wide variation in elevation, temperature, rainfall, and soil conditions. The cumulative value of established plantings of economic species is one of the advantages of a permanent arboretum of this character. The citrus and mango tree plantings constitute a valuable source of budwood, as well as being available to the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture for work on fruit fly control measures.

A series of embossed metal-tag labels, carrying the scientific name, common name, use, and origin data, was made and attached to the individual and block plantings in the arboretum and orchards. A start was made toward the establishment of exchange relationships with similar institutions throughout the Tropics. It is felt that the Economic Tropical Arboretum should prove of great value to the tropical regions in which the United States is interested and would also furnish an ideal set-up for a tropical Pacific outpost for the study of numerous problems affecting the development of tropical agriculture. The climate and health conditions are all that could be asked, while the location of the islands is such as makes them the port of call for numerous lines of trans-Pacific steamers. The reservation and other tracts of land throughout the islands offer a wide variety of soils, rainfall, wind exposure, and slope, together with elevations ranging from sea level to nearly 14,000 feet above the sea.

ANIMAL PRODUCTION

DAIRY

The dairy herd, which consists of 43 Holstein-Friesians and 11 Guernseys, serves the dual purpose of providing animals for research work and as a laboratory for students in dairy husbandry.

The general condition of the herd has been good. It is free from tuberculosis, but a fecal examination made from time to time shows that a number of the cows harbor the liver fluke.

Pineapple bran, used as a supplement to concentrates and roughages, proved equally as good as beet pulp for maintaining body weight and milk production, and at prices prevailing in Hawaii resulted in a material saving in feed costs.

A ration containing 45 and 10 percent, respectively, of locally produced cassava meal and coconut oil-cake meal was 95 percent as effective for milk production as a standard ration consisting entirely of imported feeds.

A ration containing 44 and 18 percent, respectively, of locally produced pineapple bran and cane molasses was nearly as effective for milk production as a standard ration consisting entirely of imported feeds, and at prevailing prices resulted in a saving of 32 percent in the concentrate-feed cost of milk production.

Including 25 percent of cane molasses in the rations fed to dairy cows did not adversely affect the cows or milk production and resulted in material savings in milk-production costs. The results

of this long experiment were published in a bulletin of the station (*3*) during the year.

Feeding sprouted oats to shy breeders which had been in progress for 7 years has been discontinued, as its value in Hawaii, where green feed is available the year round, has not been demonstrated. While 82 percent of such shy breeders that were fed sprouted oats finally produced calves, 76 percent of an equal number of shy breeders in the control cows also finally produced calves.

Results of feeding experiments with sprouted oats to correct sterility in cattle and swine were reported for publication during the year (*4*).

In a test comparing green alfalfa with green Sudan grass as soiling crops for dairy cows the former proved more palatable, but because alfalfa is more expensive to produce in Hawaii milk-production costs were lower when green Sudan grass was fed.

In several tests comparing green Sudan grass with green Napier grass when used as soiling crops for dairy cows Sudan grass proved somewhat more palatable, and as a result of high roughage consumption slightly higher milk production resulted in each case.

BEEF CATTLE

A locally produced feed mixture, consisting of 100 pounds of pigeonpea-hay meal, 100 pounds of corncob and husk meal, and 75 pounds of cane molasses proved effective for fattening beef steers, resulting in good and profitable gains and a good quality of beef.

SWINE

The swine herd, at the close of the fiscal year, consisted of 4 Berkshire and 5 Tamworth breeding animals and 27 miscellaneous smaller pigs.

In a feeding trial bananas, when fed to fattening swine, were worth 38 percent as much as the concentrate ration which they in part replaced.

A mixture of 84.5 percent of cassava meal and 15.5 percent of soybean oil-cake meal was worth 95 percent as much as barley for fattening swine.

Raw sweetpotatoes when fed with only a protein (fish meal) supplement did not result in satisfactory gains, but when in addition each pig was fed about 2 pounds daily of a barley-molasses concentrate mixture good gains resulted.

Feeding sprouted oats to sows that are shy breeders was continued, and while there are cases where such feeding seemed definitely helpful in bringing about pregnancy the evidence is by no means conclusive.

POULTRY

The poultry flock was reduced from 1,500 adult birds to approximately 500 during the year. Three thousand chicks were hatched to replace the adults which were sold.

The flock is maintained not only for research but also for instructional and demonstrational purposes. It consists of turkeys, guineas, and the standard breeds of chickens commonly found on the farms in Hawaii.

PLANTATION BACK-YARD POULTRY HOUSES

The object of this experiment was to develop a poultry house economical in construction and yet efficient for Hawaiian conditions. Four types of houses, each with a floor area of 72 square feet and accommodating 25 hens, were used in this project. After 2 years of experimentation, results show that egg production was maintained in a satisfactory manner in all four types; however, the birds in the "all-lath" house gave the lowest egg production due to a lack of direct sunshine within the house. In the first year of this work considerable cannibalism, in the form of feather picking, resulted from the close confinement of the birds. This past year mechanical guards were used with the result that no picking occurred. Feed consumption and egg production were normal when the guards were used. The mortality was low in all of the four houses, thus making the various types practical for the particular purpose intended. Building plans for the various types of poultry houses have been made available to interested parties.

BATTERIES FOR LAYING AND BREEDING STOCK

This report covers data gathered over a period of 2 years. Results of the first year indicated that a fermented yeast mash was beneficial to birds confined in a laying battery. The first year production averaged 200.6 eggs per bird, while the data for the first 9 months in the second trial showed an average production per bird of 181 eggs. In the second year a study was made of the fertility and hatchability of eggs produced from 2-year-old hens mated with 1-year-old males. Twenty females were stud-mated to 2 young males whose dams' egg production in the first year of laying was 260 and 284, respectively.

Of the 112 eggs set, 70 were found to be infertile, 32 with dead germs, and only 10 strong chicks were hatched. Further work on this phase of the project is necessary before reliable conclusions may be drawn. The average weight of eggs for the period was 23.4 ounces per dozen with a feed cost of 8 cents per dozen.

ARTIFICIAL ILLUMINATION FOR LAYING STOCK

For the past 3 years the 4 a. m. system, under which the lights are gradually turned on over a period of 2 weeks, and gradually reduced at the end of 6 months, over a period of 2 months, has been in use. The object of this experiment was to increase the feed consumption which presumably would increase the egg production as well as maintain body weight. Data secured over the past 3 years show that the egg production was increased 7.17 percent over a period of 6 months by the use of light. It cost 13.2 cents to produce a dozen of eggs on lights and 17 cents without lights, the feed cost only being considered. Light cost per dozen of eggs was 0.5 cent. Mortality for the 6 months on lights was 8.43 percent, no lights 8.53 percent. Body weight increased 0.56 pound during the 6-month period with no lights and 1.79 pounds on lights. This increased body weight offset the partial molt 75 percent in the lighted pens, and only 26 percent in the non-lighted pens.

TREE KALE (CHOU MOELLIER) AS A SOURCE OF GREEN FEED FOR POULTRY

Tree kale was compared with alfalfa when fed to laying hens as a supplement to a commercial laying ration. A study was made of egg production, body weight, color of yolk, size of egg, fertility, hatchability, and the weight of day-old chicks. After 3 years of experimentation the following conclusions were reached:

(1) Tree kale was found to be slightly superior to alfalfa in egg production; (2) the difference in yolk color was found to be significant, both alfalfa and tree kale producing a rich, uniform yolk color when fed at the rate of 2 pounds per hundred hens as a supplement to the regular commercial ration; (3) the size of eggs, measured in ounces per dozen for the kale was 20.82 and for alfalfa 21.01, no significant results being obtained for either supplement; (4) the weights of day-old chicks were approximately the same for each supplement, i. e., kale 37.72 grams, alfalfa 36.46 grams; (5) body weights were the same for both feeds; (6) a difference of 1.5 percent in fertility in favor of alfalfa was obtained, this, however, not being great enough to be significant; (7) the dead-germ eggs were slightly higher in the alfalfa group, but not enough so to be of importance; (8) hatchability from both feeds was high; (9) the feed cost per dozen of eggs for the supplements was 16.6 cents for kale and 17.8 cents for alfala.

RELATION OF RELATIVE HUMIDITY TO SIZE OF AIR CELL AND HATCHABILITY

The object of this investigation was to determine the optimum relative humidity for various periods of incubation. Results obtained from the first trial were not conclusive, and further work is to be done on the problem. The tentative conclusions or indications are that the lower limit of the optimum humidity range may be 50 percent and the upper limit may be 70 percent; the relative humidity has a decided influence on the size of air cell; the relative humidity increases greatly during the last 2 or 3 days of incubation; the first critical period is within the first 7 days; humidity changes in the incubator are influenced by the humidity changes in the atmospheric condition; and that a humidity of 85 to 90 percent at hatching time produces a satisfactory hatch.

FOODS AND NUTRITION

IODINE CONTENT OF HAWAIIAN MARINE FOODS

The work on iodine content described in the annual reports of the station for 1933 and 1934 was continued. The procedure for the determination of iodine in marine foods, described in the annual report for 1934 (*10, p. 27*), namely, Harry's modification of Remington's low-temperature method, was used. Experiments were carried out in duplicate. The results are given in table 1.

TABLE 1.—*Iodine content (in parts per billion of dry sample) of different marine foods*

Kind of food	Sample 1	Sample 2	Kind of food	Sample 1	Sample 2
Fish:			Fish—Continued.		
Moano	721	719	Halahu	3,975	3,230
Pupoupou	1,043	1,009	Pualu	1,453	1,416
Ukikiki	1,560	1,590	Kaku	1,086	1,192
Enenue	772	820	Crab, moala	688	700
Uu	1,615	1,690			

A study of the iodine content of eggs was begun and, after an extended investigation of methods, that of Almquist and Givens was adopted but modified by ashing the alcoholic digest at 450° C. for 12 hours instead of 600° for 4 hours. Dried eggs were used instead of fresh raw eggs. By this modified procedure, an average of 0.0075 milligram of iodine per egg was found.

STEROL CONTENT AND VITAMIN VALUE OF AVOCADO OIL

The study of the sterols of avocado oil and its vitamin D value, as described in the annual reports of the station for 1933 and 1934, was continued. The inconsistencies previously mentioned were completely eliminated and definite conclusions were reached concerning the vitamin D value of unirradiated and irradiated avocado oil and avocado sterol.

Oils were irradiated in photographic trays with ultraviolet light from a Cooper-Hewitt mercury lamp, the arc of which was arranged at 16 inches from the surface of the oil. Ether solutions of sterols were irradiated in a rotating quartz test tube placed at a distance of 16 inches from the Cooper-Hewitt arc.

In each set of feeding experiments 18 to 20 white rats were used. Wesson oil and avocado oil, irradiated and unirradiated, were fed in doses of approximately 0.27 gram per rat per day. Avocado sterol, irradiated and unirradiated, dissolved in unirradiated Wesson oil, was fed in doses of 0.0005 gram in 0.3 cubic centimeter of Wesson oil. The tibias were removed from the rats and vitamin D activity determined by means of line tests. The highest degree of healing was shown in all cases in which irradiated oils and sterols were used. No healing was shown where unirradiated samples were fed. The vitamin D activity of avocado oil and of its sterol was demonstrated.

The study of avocado sterols was extended to include preliminary studies of the sterol content of other tropical oils, namely, kukui-nut coconut-palm, chaulmoogra, and China-wood or tung oil. A method was developed for obtaining sterols quantitatively from these oils. The procedure involved preheating the oil, saponifying with potassium hydroxide in aldehyde-free alcohol, removing alcohol, extracting the sterols by means of ether, removing ether, and recrystallizing from aldehyde-free alcohol. The oils, arranged in decreasing order of sterol yield, were avocado, kukui-nut, China-wood, chaulmoogra, and coconut-palm. The yields ranged from 1.2 percent for avocado to 0.1 percent for coconut-palm oil.

A CHEMICAL STUDY OF SOME POISONOUS PLANTS OF HAWAII

THE PAMAKANI (EUPATORIUM GLANDULOSUM)

The work described in the annual report of the station for 1934 was continued, with special emphasis on the pamakani weed, a plant known to be poisonous to cattle. All parts of the plant—leaves, stems, and roots—were found to be lacking in alkaloids and cyanogenetic glucosides. Glucosides were found in the leaves and stems. Three products, apparently capable of being obtained in pure state, were isolated.

From the leaves a white, crystalline organic solid, melting at 82.5° C., substance was nonalkaloidal and noncarbohydrate in character. It could not be obtained from the stems.

From the stems a white, amorphous organic solid, decomposing before melting, soluble in hot water and insoluble in the organic solvents, was obtained. The product showed the characteristics of an inulin substance. It could not be obtained from the leaves.

From the leaves a gummy, dark oily residue was extracted with alcohol. When subjected to steam distillation this residue produced a volatile oil.

ISOLATION OF CAROTENE FROM PAPAYA

The object of this study was to isolate carotene from papaya and to correlate the amount obtained with the vitamin A activity determined for papaya by feeding experiments with rats.

The method by which excellent yields of carotene, melting at 177° C., were obtained from carrots was applied to papaya. A deep reddish-orange solution was obtained. When portions of this solution were evaporated slowly, crystals easily identified by comparison with carotene from carrots were obtained. However, it was not possible to obtain carotene crystals in quantity either by allowing the reddish-orange colored solution of carotene in petroleum ether to stand under refrigeration or by adding methyl alcohol.

Consequently, carotene from papaya was determined colorimetrically in benzene solution. One gram of papaya was found to be equivalent to 20 gammas of carotene. All results showed that the amount of carotene in papaya was much smaller than that indicated by the nutrition studies and that it was not possible to cause the small amount to crystallize out of solution as did the carotene from carrots. In view of recent reports that xanthophylls show vitamin A activity, it is suggested that xanthophylls, as well as small amounts of carotene, are responsible for the vitamin A activity of papaya as determined in the experiment with rats.

HAWAIIAN FOODS

Biological tests, using the new feeding method recommended by Sherman and Todhunter, showed the opihi to have 40 international vitamin A units per gram, a smaller value than previously obtained with the old method. It is possible that the vitamin A content of the opihi varies with the season of the year.

Biological tests showed the flesh of the Hawaiian octopus to be a poor source, but the liver an excellent source, of vitamin A.

ANEMIA STUDIES

Eighteen adult rats were made anemic by feeding them for a period of 5 to 6 months on milk low in copper and iron. Some were used as controls and others were fed definite quantities of copper and iron, and the hematopoietic response noted. Results of histological studies, not yet complete, in general parallel those found in younger animals and suggest new lines of research.

Studies are in progress to compare the hematopoietic response of splenectomized anemic rats paired with normal anemic rats when both are fed copper and iron.

PIGEONPEA CONSTITUENTS

On a moisture- and ash-free basis, the mixed globulins of pigeonpeas were found to contain 0.45 percent of sulphur. The pigeonpea-seed meal on the dry basis contained 0.22 percent of sulphur.

JAPANESE FOODS

Japanese use a great deal of salt-pickled food. In addition to salt, sake residue, miso, fermented rice, or rice bran may be used. Previous work of the experiment station has shown that a leafy cabbage (*Brassica chinensis*) and daikon (*Raphanus sativus longipinnatus*) when pickled in a paste of salt and rice bran have a higher vitamin B content than in the fresh state, owing to the fact that vitamin B of the rice bran is transferred to the vegetable. Similar results were obtained for eggplant. The Japanese long eggplant (*Solanum melongena serpentinum*), pickled in a paste of salt and rice bran for 3 days, contained 1½ to 2 times as much vitamin B as in the fresh state. The pickling process decreased the vitamin A content about half.

Commercial takuwan, daikon, pickled in salt and rice-bran paste, and long eggplant, before and after pickling, have been analyzed for organic nutrients and calcium, phosphorus, and iron. The analyses are summarized in table 2.

TABLE 2.—*Analyses of commercial takuwan and pickled and unpickled eggplant*

[Results expressed in percentage on the wet basis]

	Water	Protein	Ether-extract	Crude fiber	Carbohydrate by difference	Ash	Calcium	Phosphorus	Iron	Sodium chloride
Takuwan	85.8	1.3	0.13	0.96	4.0	7.82	0.064	0.080	0.00050	6.55
Fresh eggplant	92.6	1.1	.20	.80	4.8	.49	.010	.026	.00033	.15
Eggplant pickled in salt and rice-bran paste	87.3	1.5	.10	1.10	5.7	4.34	.012	.052	.00040	4.08

CHEMICAL COMPOSITION AND VITAMIN CONTENT OF SOME HAWAIIAN FRUITS

A study was made of the principal locally grown fruits, as to their chemical composition, vitamin value, nutritive value, and methods of propagation for use as food. A manuscript for a bulletin, giving the results of this study, was submitted for publication.

HALEAKALA SUBSTATION

Studies of the effect of varying elevations and climatic conditions on the growth of various grasses and forage plants were carried out during the year at tracts ranging from slightly over 2,150 feet to about 6,000 feet, on the slopes of the extinct crater of Haleakala. The outstanding grasses and forage plants have been adopted by the local ranch owners for extensive planting on the various cattle ranges having similar conditions.

The forage crops under test consisted of 32 species and varieties of cultivated grasses and 63 species of legumes. Mixed plats of grasses and clovers, planted in February 1934, were under observation as pasture mixtures. The 25 lots of selected pigeonpeas, planted in 1933, were reduced to 10 lots and further tested in comparison with 6 special lots received from the central station and planted May 2, 1935. At the Olinda tract (3,500 feet elevation), of 27 lots of pigeonpeas planted, 17 lots produced seed. The best eight lots were selected for future planting. During the past 12 years of breeding and selection work at the substation, no variety under test proved superior to the standard local variety known as "strain D", a selection made from Station no. 218, a planting made by the experiment station in 1906 from an introduction from Puerto Rico.

The root and tuber crops under test included 6 varieties of sweet-potatoes, 20 varieties of Hawaiian and Japanese dry-land taro, 2 varieties of cassava, 2 varieties of edible canna, and 7 varieties of potatoes.

The vegetable crops grown at the substation included 5 varieties of lettuce, 23 varieties of beans, as well as individual lots of chickpeas, garbanzo peas, tomatoes, turnips, rhubarb, asparagus, and pohas.

The cereal crops included Guam corn, White Pearl popcorn, 6 varieties of sorghum, kafir, and milo maize.

About 40 of the coffee trees planted in 1930 produced fair-sized cherries without shade. The two Panchoy winter avocados produced good crops of fruit. The strawberry guava, Natal plum, mul-

FIGURE 6.—The oriental persimmon tree grows well in many parts of Hawaii. A number of varieties are being tested in different localities by cooperative growers.

berry, loquat, purple fig, lungan, pomegranate, and Macadamia-nut trees produced fruit.

KONA SUBSTATION

The Kona substation, Island of Hawaii, completed the sixth year of its existence. This substation was established primarily for the investigation of problems affecting the coffee-growing industry, which is the principal agricultural industry of the Kona district. The development of the growing of the Macadamia nut as a supplemental industry has led the substation to give considerable attention to this crop. The apparent need of increased production of vegetables and other local food crops resulted in increased work along this line by the substation. Vegetables, such as taro, tomatoes, etc., were grown largely as intercrops between the rows of coffee, Macadamia nut, and the various fruit trees under test. The more important plantings in orchard formation under test included coffee, Macadamia nut, citrus, breadfruit, fig, mabolo, cherimoya, sugar-apple, custard-apple, mangosteen, cashew nut, avocado, litchi fruit, and persimmon (fig. 6).

These plantings made possible the study of cultivation methods, fertilizer needs, pruning, and comparative yields. In the coffee and Macadamia-nut improvement work outstanding individual trees have been selected as a source of budwood for top-working seedling trees and making ordinary grafts on the most resistant rootstocks available.

The substation has distributed a quantity of planting material of improved vegetables and fruits to the farmers of the surrounding sections. Numerous farmers have visited the substation to inspect the plantings and experiments. The results of the fertilizer tests have already caused material modification of the fertilizer practices of the entire Kona district.

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